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AUTHOR	Hofstein, Avi; Even, Ruhama
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ABSTRACT

The implementation of new standards in science and mathematics education necessitates an intensive and comprehensive professional development of science and mathematics teachers. Israel, which currently is in the process of reforming school science and mathematics, constructed a continuous lifelong framework for such professional development. This framework includes the development of science and mathematics teacher leaders. This chapter presents a detailed description of two examples of such leadership preparation in chemistry and mathematics teaching conducted at the Department of Science Teaching in the Weizmann Institute of Science. There are similarities in the structure of the two courses. However, the content and activities were designed to attain the specific nature and goals of each of these areas in general, and the aims and objectives of the curriculum developers in particular. (Contains 23 references.) (Author/MVL)

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10 Developing Chemistry and Mathematics Teacher Leaders in Israel

Avi Hofstein & Ruhama Even
The Weizmann Institute of Science

The implementation of new standards in science and mathematics education necessitates an intensive and comprehensive professional development of science and mathematics teachers. Israel, which currently is in the process of reforming school science and mathematics, constructed continuous lifelong framework for such professional development. This framework includes the development of science and mathematics teacher leaders. This chapter presents a detailed description of two examples of such leadership preparation in chemistry and mathematics teaching conducted at the Department of Science Teaching in the Weizmann Institute of Science. There are similarities in the structure of the two courses. However, the content and activities were designed to attain the specific nature and goals of each of these areas in general, and the aims and objectives of the curriculum developers in particular.

New standards in science and mathematics education are being advocated, standards which reflect the current vision of the content, classroom environments, teaching methods and support necessary to provide high quality science and mathematics education for all students (National Council of Teachers of Mathematics, 1989, 1991; National Research Council, 1996). The standards portray a direction for further reform in science and mathematics education.

The 1960s and the 1970s were the golden age of reform in curriculum development in science and mathematics. In contrast, the reform of the 1990s is characterized by both the development of new curricula and attention to teacher learning and the professionalization of science and mathematics teachers. This new focus is based on a lesson learned from the previous intensive and comprehensive efforts in curriculum development, where it became apparent that a good curriculum is necessary, but by no means sufficient, since teachers rarely use curriculum materials as intended by their developers (Romberg & Pitman, 1990).

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To illustrate this, we present an episode observed in an algebra lesson (Robinson, 1993). The lesson centered on the topic of equivalent algebraic expressions. The textbook's presentation of this topic included a task that was planned to provide meaning for the all-too-common meaningless requests in algebra lessons to simplify algebraic expressions. The students were to substitute the same fraction in two equivalent expressions, one "complex" and the other "simple." Since calculations in the former case were more complicated than in the latter, the textbook writer anticipated that students would realize that simplifying expressions is worthwhile, and would thus be motivated to learn to simplify. The class teacher knew the mathematics required and was familiar with the curriculum materials.

Following the textbook's suggestion, the teacher wrote on the board two expressions, one simple and the other complex: $4a+3$ and $\frac{3a+6+5a}{2}$ but forgot to mention that the two expressions are equivalent. Then he asked the students to substitute a fraction in both expressions:

T: Substitute $a = 1/2$.

S_1: You get the same result.

Noticing that he forgot to mention that the two expressions were equivalent, the teacher focused on this now. But instead of just stating the fact, as suggested in the textbook, he asked:

T: Are the algebraic expressions equivalent?

At this stage in their study, the students could not answer this question (this is why it was suggested in the textbook that they be told). Consequently their reactions deviated from the original plan, and they initiated a debate of this issue among themselves:

S_2: No, because we substituted only one number.

S_1: Yes.

S_3: It is impossible to know. We need all the numbers.

S_4: One example is not enough.

Clearly, the students were not engaged in the task as had been planned; however, they were engaged, on their own initiative, in a genuine and important mathematical discussion. The teacher ignored

the students' discussion completely, and adhered to the original plan:

T: We can conclude--it is difficult to substitute numbers in a complicated expression and therefore we should find a simpler equivalent expression.

While the substitution of a=1/2 in the two given expressions might lead naturally to the conclusion that "we should find a simpler equivalent expression" (as planned by the textbook writer), this was, by no means, the conclusion appropriate to the discussion that took place in that classroom at that specific moment. What students may easily learn from such experiences is that their mathematical thinking is not valued, or that mathematics does not necessarily make sense. Rather what is valued is "what the teacher has in mind" or that the teacher is the authority for determining the correctness of answers.

The above episode illustrates, simply and clearly, the critical role that the teacher has in determining the ways in which science and mathematics are taught and learned in schools, a role, which no curriculum by itself can fulfill. Such a role involves setting teaching goals and creating classroom environments in which these goals are pursued, classrooms in which students encounter, develop, and use scientific and mathematical ideas and skills in the context of genuine problems and situations, and where the teacher chooses appropriate ways to represent the subject matter, asks questions, suggests activities and guides discussions.

Past experiences suggest that knowledge of the subject matter, even at an advanced level, is not enough to equip a teacher to fulfill such a role, nor is acquaintance with ready-made curriculum materials. The above problematic teaching episode occurred in spite of the teacher's adequate mathematical knowledge and his familiarity with the curriculum materials. Teaching in the classroom is much more complicated than a straightforward implementation of a curriculum. It involves attention to classroom discourse, overt and covert messages conveyed when asking students questions, and the conduct of discussions. Consequently, in addition to content and curriculum knowledge, the teacher needs quite sophisticated knowledge about science or mathematics teaching.

Traditional ways of conducting preservice and inservice education and professional development have not been adequate (e.g., Bell & Gilbert, 1997; Loucks-Horsley, Hewson, Love, & Stiles, 1998). The

main goal of this chapter is to describe an innovative framework developed in Israel which aims at reforming the professional development of science and mathematics teachers. It focuses on the development of teacher leaders as a vehicle for providing large-scale, long-term, and dynamic inservice professional development. This framework is a part of a more comprehensive reform currently in progress in Israel in science, technology and mathematics education.

The Israeli Context

Israel has a centralized education system. Thus, the syllabi and educational projects, as well as support for teacher professional development, are conducted and regulated by the Ministry of Education, Culture, and Sport. Since the mid 1960s the Ministry has provided for a long term and dynamic process of science and mathematics curriculum development conducted mainly in Science Teaching Centers located in several academic institutions in the country. This process of curriculum development has always included implementation accompanied by assessment and evaluation (diagnostic, formative, and summative).

In 1992, the Ministry released the *Tomorrow 98 Report* (Superior Committee on Science, Mathematics and Technology Education in Israel, 1992) on reform in science, technology and mathematics education. The report includes 43 recommendations for new programs, special projects, changes and improvements, both educational and structural, in the area of curriculum development and implementation, pedagogy of science and mathematics teaching, as well as directions and actions to be taken in the professional development of science and mathematics teachers.

The report acknowledges the central role that science and mathematics teachers play in instruction, stating:

> *The best programs and the best-equipped laboratories will not prove themselves without good teachers. In the end, every subject in the education system stands or falls on the quality, qualifications and dedication of its teachers.* (p. 6)

On the basis of the report's recommendations, the Ministry decided to create a setting that would support on-going learning for teachers. A series of regional teacher support and guidance centers were established (mostly located in teacher colleges around the country). These centers offer various types of inservice courses for

the science and mathematics teachers in the region; most of them are one day a week (4-8 hours per day) throughout the school year. The establishment of the regional teacher centers reflects the Ministry's acknowledgment of both the need for teachers to learn to teach in new ways, and of the need for life-long professional development for teachers. More specifically these centers' main goals are to:

- Provide for continuous and sustained support for professional development of science and mathematics teachers.
- Provide science and mathematics teachers with opportunities to engage in life-long learning.
- Create an environment of collegiality and collaboration among teachers who teach the same or related subjects, an environment which encourages reflection on their work in the classroom.
- Incorporate the process of change into professional development (some examples include curriculum change and new and varied instructional techniques).

This large-scale professional development framework is supported and guided by national teachers' centers (usually located in academic institutions in which the main curriculum development is conducted). The overriding aim of the national centers is to encourage educational reform by providing a strong framework to support teacher development. They are responsible for the following activities:

- Development of teacher leaders who will initiate, support, conduct and lead professional inservice development.
- Counseling and support for the regional teacher centers and other regional professional development activities for teachers.
- Development and establishment of high standards in the pedagogy of mathematics and science teaching and learning.
- Development of models for effective professional development of mathematics and science teachers.
- Establishment of a clearinghouse for relevant computer assisted instruction, special experiments, and relevant instructional methods and programs and curricula from all over the world.
- Dissemination at the national level of relevant professional information.

In this chapter, we focus on the development of teacher leaders in the national centers. The teacher leaders' role is to promote teacher learning in regional teacher centers or in other regional and local institutes. The following sections describe two different examples of such programs, each tailored to the needs and goals of the subject as seen by those responsible for these programs. One deals with the professional development of chemistry teacher leaders; the other with the professional development of mathematics teacher leaders. Both programs are two years long (450 hours) and are conducted at the National Chemistry and Mathematics Teacher Centers (respectively) in the Department of Science Teaching in the Weizmann Institute of Science.

Professional Development of Chemistry Teacher leaders

Profile of prospective leading chemistry teachers

The course is open to chemistry teachers who are considered to have the potential to become teacher leaders. These teachers share the following characteristics, more specifically they:

- Serve as chemistry coordinators in their respective schools.
- Have at least 10 years experience in teaching high school chemistry (10-12th grade), including experience in preparing students for matriculation examinations.
- Have participated in a number of inservice professional activities.
- Were recommended by regional tutors as creative and open to changes in science education in general and chemistry teaching in particular.

Structure of the course

The philosophy that underlines the course is that, in recent years, there has been a major change in our perception of the content and pedagogy of chemistry teaching and learning. To reform the content and pedagogy of chemistry teaching, there is a need to educate leaders who will eventually serve as agents for change.

It is suggested that in order to become a leader, the chemistry teacher has to undergo a multiple phase development. The development should include the following dimensions: the new scope of high school chemistry (content knowledge), the improvement of the pedagogy

of high school chemistry (pedagogical content knowledge), and the knowledge and skills to develop the teacher as a leader who serves as an agent for change. The following discussion is an elaboration of these dimensions.

The New Scope of High School Chemistry (Content Knowledge)

The aim here is to provide the potential teacher leaders with the scientific (chemistry) content that they lack. In recent years, science educators in general and chemistry educators in particular have realized that science is taught not only to prepare students for an academic career in the sciences (in our case, chemistry), but also to become citizens in a society that is highly influenced by scientific advances and the accompanying technological manifestations. Consequently, chemistry should be taught with appropriate emphasis on its relevance to everyday life and its role in industry, technology and society.

This view was the basis for the claim made by Kempa (1983) that future development of teaching and learning material in chemistry should include the following six dimensions:

- Knowledge and information about chemical transformation and processes and associated principles, concepts and theories-including concepts and principles based on recent investigations (i.e., presenting the frontier of the science).
- Chemistry as an inquiry based discipline, which gives rise to new knowledge and insights and allows problems to be solved both in the classroom as well as in the laboratory. While learning chemistry using the inquiry method, students are able to ask questions, plan and conduct investigations, think critically, construct and analyze alternative explanations and communicate scientific arguments (Bybee, 1997).
- Chemistry as an applied science of major economic and technological importance.
- Chemistry as a subject of distinct personal relevance through its everyday application and uses.
- Chemistry as a human and cultural activity, manifesting itself in the growth of ideas, the development of industries and its influence on peoples' life styles.
- Chemistry as a subject of major social and environmental implications.

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This new approach emphasizes the application and relevance of chemistry to everyday life, and is expected to increase students' motivation to learn chemistry. This approach to high school chemistry makes great demands on the chemistry teacher, and only intensive professional development procedures can affect and change teachers' knowledge and beliefs regarding the content and scope of high school chemistry.

During the course the potential teacher leaders are exposed to the above dimensions. They are involved in activities which enable them to integrate the chemistry subject matter with information from the literature of how students learn and construct their knowledge, as well as how to anticipate students' learning difficulties.

The Improvement of the Pedagogy of High-School Chemistry (Pedagogical Content Knowledge)

This dimension concentrates on activities aimed at improving the chemistry classroom and laboratory learning environment. The course participants are exposed to a variety of instructional methods and are also provided with situations that give them opportunities to reflect on their work and experiences. It is based on the assumption that to help others to change, they should first affect change in their own classes and schools.

As mentioned before, the present era is characterized not only by new standards in the content of science, but also by the way science is taught; namely, the pedagogy of science teaching. It is suggested that, curriculum materials and instructional strategies should be tailored to the cognitive abilities and aptitudes of different students. The overall objective is to create a learning environment which allows students to interact physically and intellectually with instructional materials through hands–on inquiry oriented activities.

Hofstein and Walberg (1995) and Tobin, Capie, and Bettencourt (1988) presented evidence that instructional techniques in science should be matched with the learners' characteristics and needs in order to maximize the effectiveness of the teaching and learning processes and also to increase student motivation. Hofstein and Kempa (1985), who postulated that some relationships exist between students' motivational traits (characteristics) and their preferences for particular teaching and learning strategies, also provided support for this idea. This was confirmed in a quantitative research study conducted in the United Kingdom by Kempa and Diaz (1990).

Clearly, in practice, it is difficult to respond to each student's needs, but much can be achieved if teachers use a wide repertoire of instructional strategies, instead of limiting themselves to only one or two. To do so, requires not only skills and knowledge in a variety of teaching methods, but also leadership (managerial) competence to implement these methods in schools, regions and the whole education system. This clearly represents a major challenge to professional development for teachers and educators.

During the course, the participants obtain experience in the following instructional techniques:

- Cooperative learning.
- Simulation games and debates (role-playing).
- Educationally effective field trips (e.g., chemical industry).
- Critical reading of articles in newspapers and scientific journals.
- Inquiry type laboratories and other inquiry type assignments.
- Students' personal chemistry based projects.

Varying classroom instruction implies the use of alternative methods for assessing student progress and achievement. Teachers need to be aware of the different modes of assessment. For example, research on achievement in chemistry (Hofstein, Ben-Zvi, Samuel, & Kempa, 1977) and in biology (Tamir, 1972), has clearly shown that achievement using paper and pencil tests is not well correlated with achievement in practical type tests. The course participants learn how to organize a portfolio to obtain a comprehensive and objective picture of their students' achievement and progress.

The Teacher as a Leader: An Agent for Change

On the basis of research on professional development and change in schools, it is clear that leadership is required for professional development experiences to be turned into changes in teaching and learning (Fullan, 1991). The central goal of the course is to develop chemistry teacher leaders who will foster such change in chemistry education. In particular they should be able to:

- Facilitate communication among and cooperation between teachers.
- Initiate school and regional based curriculum development implementation and evaluation.

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Thus, the course participants are guided in methods of conveying the ideas discussed in the leadership course to their peers in schools and to workshop participants in the regional centers. The course aims to develop understanding of leadership, including the bases of power and different leadership styles. The course participants are also involved in workshops aimed at developing skills in decision making, building and managing teams, conflict resolution, problem solving, vision building and communicating, and skills for managing diverse types and characteristics of teachers. All these aim specifically at the reform of the content and pedagogy of chemistry teaching.

These abilities are mainly developed through workshops devoted to educating the leading teachers to become developers and disseminators of curriculum materials in chemistry. For example, a course participant who wished to teach a particular topic in a class which was heterogeneous, both in student ability and also in student preferences for a certain learning technique, became a school based curriculum developer. He was encouraged to vary and tailor the learning material to suit the students' characteristics, with the aim of overcoming motivational obstacles as well as cognitive barriers (i.e., misconceptions and other learning difficulties).

In this and other ways, the course participants are provided with the know-how to alternate the curriculum and the assessment, in order to make it more appropriate to their school structure and its students' special needs and characteristics. As appropriate academic knowledge they are exposed to the literature about conceptual change, learning difficulties and other cognitive and affective variables that influence effective learning in science in general and in chemistry in particular. A long-term aim is to obtain an appropriate blend of materials developed by professional curriculum centers with materials developed by teachers.

The 'teacher based' approach to curriculum development used in the leadership course result in the development of many pedagogical ideas and innovative approaches to the present curriculum, which is in its implementation phase. The teacher leaders are involved in the process of matching the chemistry curriculum to the special structure and needs of their schools by working in teams in the course and then working with teams of chemistry teachers in their schools. The leading teachers are guided in the process of managing and building 'team work' in their particular schools with their fellow chemistry teachers. Most of the 'team work' focuses on reducing the school teachers'

anxiety towards the introduction of new topics, new instructional methods and new assessment tools with the aim of varying and improving the chemistry classroom learning environment.

During the leadership course, with the help, guidance and support of the course instructors and peers, the participants are given opportunities to reflect on their fieldwork and thus obtain feedback for the purpose of further development of leadership abilities. This is conducted by what is called an 'open platform' for dealing with problems that emerge in their daily work. This platform supports the development of an environment of collegiality, the ability to share ideas, to critically evaluate new ideas, to openly discuss new ideas and reach conclusions and decisions, and to develop skills of working with other teachers.

Professional Development of Mathematics Teacher Leaders

As in chemistry, the role of mathematics teacher leaders and in-service teacher educators becomes especially important at this time of considerable reform in mathematics education. As conceptions of the teacher role are changing, teachers are expected to act as professionals and decision makers. Teacher leaders can enhance reform in school mathematics by joining curriculum developers, researchers in mathematics education, and decision makers in the educational system. Collectively they can play a major role in setting educational policy and goals, and leading and enhancing the professionalization of teachers. However, such a role requires adequate preparation--a preparation which was missing in Israel when the *Tomorrow 98 Report* (1992) was published.

Teacher leaders and educators require not only adequate preparation but also adequate resources. Similar to the need for instructional materials for both children and teachers in the classroom, teacher leaders and educators require materials developed for the purpose of planning learning experiences in teacher education programs or in professional development activities. The *Manor Project*, a major component of the National Mathematics Teacher Center (Superior Committee on Science, Mathematics, and Technology Education, 1992) responds to both these needs. It aims:

- To prepare promising mathematics educators to serve as leaders, guides and support for secondary teachers in the process of changing and improving mathematics teaching.

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- To develop resource materials for project participants and other mathematics teacher educators for their work with teachers.

The following sections describe first the preparation program, and then the resource materials.

The Manor Preparation Program

The program emphasizes the following:

- The development of understanding about current views of mathematics teaching and learning (e.g., NCTM, 1989, 1991).
- The development of both leadership and mentoring knowledge and skills as well as methods for working with other teachers.
- The creation of a professional reference group.

The program started in the 1993-1994 school year and is now running for the third time. It extends over two years in an effort to allow sufficient time for the participants to learn, experience, and experiment with the topics and ideas encountered. Further, experience suggests that there is a need for development and growth in the participants' conceptions, beliefs, and dispositions about the nature of mathematics learning and teaching and about teaching teachers. Such change requires time to be effective. After graduation, the participants are invited to participate in a monthly forum.

Selection for the program is based on the following criteria: (a) a first degree either in mathematics or in a mathematics-related field, such as a B. Ed. with a mathematics major or a B. S. in chemistry; (b) experience in mathematics teaching and experience in inservice work with mathematics teachers, at least one of them at grade nine or above; (c) agreement to conduct weekly inservice work with a group of secondary mathematics teachers during the program; (d) reputation as a successful teacher with the potential to become a good teacher leader or teacher educator; and (e) a reasonable spread of participants across the country.

During each school year, the participants meet weekly for six hours with project staff and guest lecturers, and conduct weekly two-hour professional development activities, some explicitly focused on initiating change in mathematics teaching and learning. As an overall assignment for each year, the participants prepare portfolios that document their learning experiences. Participants receive feedback on partial drafts several times throughout the year both from project staff and from their peers in the program.

Detailed description of aspects of curriculum design and the theoretical rationale for the learning opportunities provided by the Manor Program are described in Even (in press-a). Even (in press-b) examines one component of the Manor Program which is designed to encourage integration of academic knowledge with knowledge learned in practice, in order to challenge the participants' existing conceptions and beliefs and promote intellectual restructuring. In the following section, we describe the program's focus on three types of development that seem essential to the teacher leader and teacher educator role: personal, professional, and social.

Adapting Bell and Gilbert's (1994) use of these terms from the context of teacher development to the context of teacher leader and teacher educator development, we take the term 'personal development' to mean an affective development which involves attending to feelings about the change process, being a teacher leader, and mathematics education and teacher education. 'Professional development' involves changing concepts and beliefs about mathematics education and teacher education, and changing teacher education activities. 'Social development' involves working with and relating to other teacher leaders, educators, teachers, principals and superintendents in new ways.

Personal development. An important goal of the personal development aspect of the program is to help participants develop professional sense and confidence. All program participants have already conducted inservice work with secondary teachers in various projects, or have served as mathematics coordinators in their own schools. However, when entering the program, many do not consider themselves teacher leaders or teacher educators. In many cases, they are not sure what this role really entails, and they feel that they do not have the knowledge nor the skills to lead teachers towards learning about mathematics teaching and changing the traditional practice of school mathematics. In an effort to promote the participants' professional self-esteem, we help them expand their knowledge in several fields related to their work (this is described in the next sub-section).

Also, in contrast to the usual in-service courses for teachers in Israel, the Manor Program includes an advanced academic component for which the participants receive graduate credit. In addition to encouraging participant commitment and work investment in the long-

term program, this component also encourages the development of professional self-esteem. The message, that they are expected to be part of the leadership to improve mathematics teaching in the country, is also emphasized in words and in actions. We approach the participants as professionals, expecting them to take their work in the program and in the field very seriously, and to respect each other's contributions. Most of those who complete the program report that they have made progress in self-confidence, desire for continuous learning and development, and willingness to accept challenging leadership roles (Even, in press-a).

Professional development. With the aim of changing concepts and beliefs about mathematics education and teacher education, the program centers on mathematical, cognitive, curricular, pedagogical, technological, and social aspects of teaching different mathematical topics. Also, the program examines critical educational issues, enhances mathematical knowledge, emphasizes the development of leadership skills and methods for working with teachers. In addition, the program encourages discussion of practical difficulties and dilemmas and focuses on initiating change in school mathematics teaching and learning.

A factor that characterizes many of the learning experiences offered in the program is the connection between theory and practice. Changing concepts and beliefs about mathematics education and teacher education are intertwined with changing teacher education activities. For example, throughout the program the participants conduct weekly two-hour professional development activities based on what they learn in the course. Participants describe and analyze them in writing on a regular basis, to encourage serious reflection. They receive feedback on their reports from program staff as well as an on-going support in preparing the teacher development activities.

Moreover, most of the final year is devoted to learning how to plan, conduct, and evaluate change initiatives. Emphasis is put on connecting what is learned in the more theoretical components of the program with the issue of actual change in school mathematics. Each participant chooses an aspect of school mathematics on which to work with the teachers in school (e.g., building a mathematics room, helping to prevent at-risk high school students from dropping out and not matriculating, developing a program for student projects, using new technologies). Those who choose the same topic form a team coordinated by a staff member or one of the participants.

Each team member works within the framework of the team topic but has autonomy to plan, conduct, and evaluate the project, according to the work conditions, the teachers involved, the student population, and personal preferences. Team members meet to discuss their work, plan activities, consult with one another, share and discuss ideas, support each other, and explore ways of implementing their plans and evaluating the implementation. In addition, several whole-group meetings are devoted to theoretical aspects of initiating change in school mathematics, such as planning change initiatives, the critical role of the teacher in the success of long-term educational change, fundamental barriers to change related to the nature of teaching, and various ways of evaluating change initiatives. To encourage the participants to reflect on their experiences, they are required to submit a detailed report as the main part of the final year's portfolio.

At the end of the program the participants come to realize that change in school mathematics is a slow and complicated process, and better understand what is entailed. They gradually pay more attention to the needs and desires of the teachers with whom they work, and they are able to identify alternative possible actions and make sound choices. The content and the topics of the teacher development activities they conduct also change. Participants become richer in their knowledge and skills as they pay more attention to teacher learning about learning processes and students' conceptions and ways of thinking. Additionally, they examine student assessment seriously and include cooperative analysis of events that the teachers in the group experience. In the conduct of teacher development activities, the participants gradually encourage active participation of the teachers, start to use technological tools, and emphasize the development of teamwork. The program participants' reflective abilities also develop considerably, until they are able to criticize the teacher development activities they themselves conduct and suggest modifications.

Social development. When beginning the initiatives, quite a few of the participants use the common didactic approach of *telling* the teachers with whom they work what to do and how to do it. Later, they learn that it is important for the teachers to have a sense of ownership, and they start to encourage the teachers to participate in the planning, decision making, assignment of roles, setting of time tables, and sharing of responsibilities--key points for successful professional development work with teachers (e.g., Clarke, 1993; Loucks-Horsley et al., 1998). The initiation of change provides numerous opportunities

for new ways to work with other people in the educational system such as principals, superintendents, and home-room teachers.

The program also emphasizes learning to work in new ways with other teacher leaders and educators. Several studies (e.g., Fullan, 1990; Loucks-Horsley et al., 1998; McLaughlin, 1991) suggest that teacher collegiality and collaborative work environments are critical to change. We expand this idea to include teacher leaders and educators' collegiality and collaboration. Throughout the program we emphasize the development of a professional community. For example, the participants conduct several tasks in teams and make team presentations. We encourage them to open their work to colleagues, both for critique and use. Teachers read each other's yearly portfolios for feedback and give oral presentations to other course participants, to other mathematics educators in national conferences and meetings, and to administrators such as school principals and superintendents.

Manor Resource Materials

To teach effectively, teachers need materials such as textbooks, teacher guides, educational software and enrichment materials. Similarly, if inservice teacher learning is taken seriously, teacher educators need materials that are developed for the purpose of planning and executing learning experiences for inservice teachers. Thus, the Manor Project staff members develop research-based materials for use by teacher educators and teacher leaders (either the Manor Program participants or others). The guiding principle in designing the materials is that teacher leaders and in-service teacher educators should enhance teacher learning, where the role of the teacher changes from one who only implements expert-made curriculum materials, to one who sets subject matter goals and creates classroom environments to pursue them; from one who only implements decisions made by "knowledge owners," to one whose professional knowledge is broad and who can make professional decisions thoughtfully.

Three resource files have so far been developed on the topics of algebra, functions and pi. The major themes in these files are:

- A historical view on the main topic of the file.
- Selected mathematical aspects relevant to teaching the topic.
- Students' conceptions and ways of learning and thinking.
- Aspects of mathematics lessons and teaching.

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The resource files contain detailed suggestions for teacher development meetings on the above themes such as mathematical, cognitive, social, and didactic aspects of teaching and learning. All suggestions were tried in previous inservice activities, including the Manor Program. In addition, they contain a classified list of articles, books, journals, and other references that can assist teacher educators and teacher leaders in their work.

The content of some of the suggested meetings is specific to the file's topic (e.g., historical view on the development of algebra, different representations of function, students' conceptions of pi) while others emphasize more general teaching and learning aspects in mathematical contexts (e.g., characteristics of a "good problem" in school algebra, comparative analysis of textbooks on functions).

Several models for teacher development meetings are exemplified, in order to suggest and illustrate ways of conducting such meetings. The aim is to convey the message that there is more than one way. All models are based on current ideas and conceptions about student learning of mathematics, modified to fit the context of teacher learning about mathematics teaching. Some examples include: encouraging teachers to explore and struggle with complex problems in the teaching of mathematics, emphasis on long-term investigations of problems, providing opportunities for cooperative learning, and supporting the development of powerful tools to solve problems in mathematics teaching.

Most entries in the resource files are presented in considerable detail with the aim of "portraying" a concrete, tangible picture of potential teacher development meetings including the rationale, atmosphere, ways of work, nature of discourse and materials. The suggested meetings include questions the teacher educator might wish to ask, responses that teachers who participated previously in such a meeting suggested and possible actions. In many cases, alternative suggestions are offered, as well as follow-up activities. Also, many teaching aids are included (e.g., worksheets, transparencies, video clips for illustration and discussion). In addition to the detailed entries there are also several less detailed suggestions which the users of the file can develop further.

The entries are developed to serve as a resource, model and guide; and indeed, teacher leaders and educators use the resource files in various ways to suit their context, taking into account the teachers

with whom they work, the time available, and their own professional and personal preferences. For example, teacher educators use the materials as (a) a script and almost replicate the suggested activities, (b) as a resource for designing a different activity, and (c) as a source for professional development of the teacher educators themselves with no immediate use with teachers in mind.

Summary and Conclusions

Until the 1990s, most of the efforts in trying to achieve desired changes in school science and mathematics centered on the development of improved curricula. In the last decade, more attention has been gradually given to the teacher, as past educational reform efforts suggested that the teacher plays a critical role in the ways reform ideas are implemented in the classroom. It was realized that teachers' need to learn to teach in new ways cannot be ignored. Consequently, there was a need to change inservice work with teachers. The establishment of regional teacher centers creates a comprehensive framework that can provide opportunities for inservice teachers for life-long learning in their profession.

This chapter focuses on the development of teacher leaders in chemistry and in mathematics, part of a national endeavor to improve science and mathematics teaching and learning in Israel. After graduation, most fulfill the role of a teacher leader and educator, either in the newly-established regional teacher centers, in other local institutes that provide professional development for teachers, in their own school (as chemistry or mathematics coordinators), or in other schools. In addition to their leadership roles, most continue to teach chemistry or mathematics at school. Participating in the course is not a one time connection with the national teacher center, as most of our graduates continue to be in close contact with the center, either by regular or electronic mail, participation in one day workshops and lectures, or participation in a monthly forum.

In a summary questionnaire, the participants reported that participating in the teacher leaders' courses contributed to their being able to initiate and conduct change in school chemistry or mathematics, provided them with leadership knowledge and skills, expanded their teaching knowledge and skills, acquainted them with major figures in academia and the educational system, and motivated them to pursue further professional development and even graduate

studies. Interviews with a sample of the participants and informal talks with others provided similar results.

Achieving scientific and mathematical literacy for all has become a national goal for education in many countries. Although admirable, the goal represents a challenge for science and mathematics teachers and for those responsible for professional development. Achieving this goal must be accompanied by reform in the way science and mathematics is taught in schools. Thus far, there is little literature which describes models and case studies that can help in building an educationally effective framework of professional development, especially in the development of leadership. The Israeli experience, described in this chapter, is intended as a small contribution in this direction.

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